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Chapter 5

The Role of Nutrition in the Management of Diabetes Mellitus

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1. Introduction

Scientific evidence abound to show that the prevalence of diabetes mellitus(DM) is increasing around the world at a rate that appears dramatic as to have been characterized as an epidemic[1]. Among several factors that have been postulated to contribute to DM epidemic, environmental factors have drawn particular attention because of the rapidity of the increase in type 2 or the so called 'maturity on- set' diabetes mellitus. Nobuko Seike, Mitsuhiko Noda and Takashi Kadowaki [2] evaluated the association between alcohol consumption and the risk of type 2 DM, it was pointed out that type 2 diabetes mellitus is closely related to life style factors including diet, physical activities, alcohol and smoking as well as obesity and a family history of diabetes. According to the researchers, in Japan the prevalence of diabetes mellitus both for men over age 50 and women over 60 well exceeds 10% and most have type 2 DM which is associated with excessive energy intake, lack of physical exercise and obesity. In addition, Mayes and Botham[3] revealed that obesity – particularly, abdominal obesity(a diet related disorder) is a risk factor for increased mortality, hypertension, type 2 DM, hyperlipidaemia and various endocrine dysfunctions.

On the other hand, type 1 DM, or 'Juvenile DM' or 'insulin-dependent' diabetes is less common than type 2. Only 10% of all diabetics have type 1.

Type 1 diabetes occurs when the pancreas produces no insulin at all. It tends to emerge in childhood or early adulthood (before the age of 40) and must be regulated by regularly injecting insulin. Although the exact cause of type 1 diabetes is currently unknown, it is widely believed that majority of type 1 diabetes is of the immune-mediated nature, where beta cell loss is a T-cell mediated autoimmune attack [4].

With type 1 diabetes, the immune system attacks cells in the pancreas. This destroys or damages them enough to stop the production of insulin. A number of experts attribute this occurrence to a viral infection.

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Genetics are also thought to play a part in the cause of type 1 diabetes; it has often been seen to run in families.

People who have a close relative (parent or sibling) with type 1 diabetes have a 6% chance of developing type 1 diabetes too.

In some instances, type 1 diabetes can be caused by a condition of the pancreas known as 'chronic pancreatitis'. Chronis pancreatitis causes an inflammation of the pancreas and can cause serious damage to the cells that produce insulin [5].

It is a well known fact that DM being a metabolic, endocrine disorder is directly connected to carbohydrate, lipid and protein metabolism. As a result, nutrition therapy forms an integral part of diabetes management and diabetes self - management education. It is also well established that diabetes is caused by either a lack of Insulin secretion or by insulin resistance. The resultant disease or metabolic disturbance leads to hyperglycaemia and dyslipidemia in the short term, as well as long term complications such as retinopathy, neuropathy and nephropathy. Besides, persons with diabetes are 2 to 4 times more likely to develop coronary artery disease or to suffer a stroke. Findings from the diabetic control and complication trials (DCCT) and the United Kingdom prospective Diabetes study(UKPDS) clearly indicate that the maintenance of near normal blood glucose level dramatically reduces the chronic complications associated with this disorder. In addition, reducing elevated blood lipids levels has been shown to lower the incidence of acute coronary events in other at-risk populations. Research have shown that before the advent of insulin therapy in the early 20th century, medical nutrition therapy (MNT) was the only form of therapy for DM[6].

However, there are many misconceptions concerning nutrition and diabetes [7]. Moreso, most diabetics are confused with conflicting nutrition advice and opinions. And it is commonly believed that diabetes cannot be completely cured , but it may be more easily regulated and controlled with the right diet . With strict adherence to nutritionist's advice, diabetic patients may be able to significantly improve their quality of life. There is little data on the role nutrition played in diabetes management in our environment, hence, the need for a review like this.

2. Diabetes mellitus and nutrition

A number of nutritional factors have been found to influence the development of type 1 diabetes or type 1-related autoimmunity. One study has found, for example, that eating vegetables daily during pregnancy reduced the risk of a child's developing type 1-associated autoimmunity [8]. Another found that higher iron intake (via infant formula or supplements) in the first four months of life was associated with a higher risk of developing type 1 diabetes[9]. However, other studies have not found associations between diet and type 1 diabetes development. For example, Virtanen et al.[10] found only a weak protective effect of a few foods eaten during pregnancy and the development of type 1 related autoimmunity in the offspring (those foods were butter, low-fat margarine, berries, and coffee; most foods showed no association).

2.1. Omega-3 fatty acids

Norris et al.[11] found that dietary intake of omega-3 fatty acids, found in fish, flax seeds, walnuts, soy, canola, and greens, is protective against the development of type 1 diabetes-related autoantibodies in children at genetic risk of type 1 diabetes. Omega-3s can reduce inflammation, and the lack of omega-3s in Western diets may predispose people to inflammation. Yet the same authors later found that omega-3 levels were not associated with later development of type 1 in these children [12]. So, it is possible that omega-3s may be protective against type 1 autoantibody development, but be less significant later in the disease process.

An earlier study of the same children found that the mother's dietary intake of omega-3 fatty acids during pregnancy did not affect the risk of autoimmunity in children [13]. Cod liver oil, however, taken during pregnancy, has been associated with a reduced risk of type 1 diabetes in offspring. Both omega-3 fatty acids and vitamin D are present in this oil, and either or both may play a role [14].

Virtanen et al.[15] found that the fatty acids associated with milk and ruminant meat fat consumption were associated with an increased risk of type 1 related autoimmunity. Linoleic acid, however, was associated with lower levels of autoimmunity, in children genetically at risk of type 1 diabetes.

A group of people with metabolic syndrome (a group of conditions common in people with type 1 or 2 diabetes) were given omega-3 fatty acid supplements or a placebo for six months. Those taking the supplements were found to have lower markers of autoimmunity and inflammation, as well as more weight loss, compared to people who did not take the supplements [16].

Adequate intake of omega-3s during pregnancy may also decrease the risk of obesity in the offspring. Higher levels of omega-6 fatty acids in relation to omega-3s in umbilical cord blood has been associated with higher obesity in children at age 3 [17].

2.2. Chemicals and omega-3s

The presence of environmental contaminants in food may also play a role in the effects of nutritional factors. Some contaminants may interfere with the beneficial effects of foods. For example, in a study linking insulin resistance to persistent organic pollutants, the researchers concluded that beneficial aspects of omega-3 fatty acids in salmon oil could not counteract the harmful effects caused by the persistent organic pollutants in that oil [18].

Fish is one source of omega-3 fatty acids, but according to an editorial in the *American Journal of Clinical Nutrition* (AJCN), it may be better to rely on plant-based sources instead [19]. Studies on fish consumption and type 2 diabetes are inconsistent: some show that higher dietary intake of omega 3s decreases the risk of type 2, some show no connection, and some even show that higher fish consumption increases the risk of type 2 diabetes [20,21]. It may be that the chemicals in fish can explain these inconsistencies. A study shows that plant-based omega 3s have different effects than marine-based omega 3s in relation to type 2 diabetes [22], it was opined that this may be possibly due to the contaminants present in fish.

A high fat diet, especially one high in saturated fats, has been linked to type 2 diabetes and insulin resistance. It appears that saturated fatty acids (but not unsaturated fats) activate immune cells, which produce an inflammatory protein, which in turn then makes cells more insulin resistant [23].Mothers who consumed higher levels of trans fats had an increased risk of excess body fat, and so did their breastfed infants [24].

Can the effects of a high fat diet be passed down to subsequent generations? In animal studies, a high-fat diet that causes obesity in mothers can affect the metabolism and weight of her offspring. But what about a high fat diet in fathers? In one study, the female offspring of heavier father rats (fed a high-fat diet) had defects in their insulin and glucose levels, like their fathers. Unlike their fathers, they were not heavier than the controls [25]. Other researchers fed mice a high fat diet with fat composition similar to a standard Western diet, and then bred them and fed them the same diet for multiple generations. Over four generations, the offspring became gradually heavier, and developed higher insulin levels, despite not eating more calories. The diet was associated with changes in gene expression [26].

2.3. Glycemic index and sweeteners

The glycemic index(GI) is a measurement of how high a certain food raises blood glucose levels after it is eaten. Foods that have a high glycemic index will cause blood glucose to rise more, triggering insulin production (in people who still produce insulin), then leading to falling blood glucose levels. One prospective study has found that a higher glycemic index diet leads to a faster progression to type 1 diabetes. The group of people on this diet, however, did not have higher levels of autoantibodies, showing that the diet may affect disease progression but not disease initiation. The mechanisms involved may include oxidative stress, caused by high blood glucose levels after meals, or perhaps insulin resistance. Whatever the mechanism, a high glycemic index diet may place additional stress on beta cells that are already under an autoimmune attack [27].

Evidence favouring the active reduction of blood lipids continues to accumulate and several major diabetes associations now recommend that diabetic patients should reduce fat intake and increase carbohydrate intake to approximately 50% of total calories[1]. High fibre foods has been advocated [28]. It was highlighted that, although before detailed advice can be given, comparative data on the physiological effects of carbohydrate foods may be required.

The consumption of sugar-sweetened beverages has been associated with type 2 diabetes, obesity, and metabolic syndrome. A meta-analysis of a 11 prospective studies (of over 300,000 people) found that those who consumed 1-2 sweetened beverages per day had a 26% greater risk of developing type 2 diabetes than those who consumed fewer than one serving per month. The risk was 20% higher for developing metabolic syndrome. Sugar-sweetened beverages include soft drinks, fruit drinks, iced tea, and energy/vitamin water drinks [29].

High-fructose corn syrup is another sweetener linked to obesity. Rats given access to high-fructose corn syrup gained more weight than those given access to sucrose, despite eating the same number of calories [30].

2.4. Zinc

A few studies have found that higher zinc levels in drinking water may be protective against type 1 diabetes. For example, Zhao et al. [31], found that higher levels of zinc and magnesium were associated with lower rates of type 1 diabetes in southwest England. In Norway, a study found that higher zinc levels in water was associated with a lower risk of type 1 diabetes, but the association was not statistically significant [32]. In Finland, a study found that low zinc levels in drinking water was associated with a higher incidence of type 1 diabetes [33].

2.5. Nicotinamide and other antioxidants

Nicotinamide, is a component of vitamin B_3 that has been shown to protect against diabetes in animals, and prevent beta cell damage [34]. Even better, one study found that it prevented the development of type 1 diabetes in children with type 1-associated autoantibodies [35].

On the basis of these and other studies, a large, double-blind, placebo-controlled trial was conducted in Europe, the U.S. and Canada, called the European Nicotinamide Diabetes Intervention Trial (ENDIT). This trial gave nicotinamide to first degree relatives of people with type 1 diabetes who already had developed type 1-associated autoantibodies. Unfortunately, it found no difference in the development of diabetes between the two groups during the 5 year follow-up period. The study gave high doses of the vitamin, up to 3 g/day (30-50 times higher than the RDA) [34].

Another double-blind, placebo controlled study in Sweden gave high doses of anti-oxidants (including nicotinamide, vitamin C, vitamin E, Beta-carotene, and selenium) to people after they were already diagnosed with type 1 diabetes and also found that they had no effect in protecting the beta cells against the damage of free radicals [36]. There is no evidence linking the anti-oxidants alpha- or beta-carotene levels and the development of type 1 related autoimmunity in another study as well [37].

Uusitalo et al. [38] also found that if pregnant women took anti-oxidants and trace minerals (including retinol, beta-carotene, vitamin C, vitamin E, selenium, zinc, or manganese) during pregnancy, there was no effect on the risk of the child's developing type 1-related autoimmunity.

Czernichow et al.[39] found that anti-oxidant supplements were not protective against metabolic syndrome, a group of conditions common in people with type 1 or 2 diabetes. Yet they also found that the people who had the highest levels of some anti-oxidants (beta-carotene, vitamin C, and vitamin E) in the beginning of the study, presumably due to a diet rich in plant foods, did have a lower risk of developing metabolic syndrome.

While these studies did not find promising results concerning anti-oxidant supplements, they also did not find that these supplements did any harm.

Free radicals may play a role in the inflammatory process that destroys the beta cells in type 1 diabetes [36]. Therefore, anti-oxidants have been thought to protect the body from oxidative

stress due to the production of free radicals. But, there is some animal evidence that anti-oxidant supplements may also increase insulin resistance, showing that the relationship may not be so simple. When the researchers gave certain mice an anti-oxidant, they were more likely to become insulin resistant [40]. Perhaps this finding could help explain why anti-oxidant supplements have not been found to be protective against type 1 diabetes.

3. Food processing: AGEs

Advanced Glycation End products (AGEs)are found in heat processed foods and have been linked to type 1 and type 2 diabetes in animal studies. They appear to predispose people to oxidative stress and inflammation, and may affect the fetus if the mother consumes them during pregnancy. A study has found that the level of AGEs that a mother eats are correlated with insulin levels in the baby. It found that if mothers have high AGE levels, and infant food is high in AGEs, it may raise the risk of diabetes in the offspring [41].

3.1. Protein

Researchers fed mother rats a diet that was deficient in protein, and found higher rates of diabetes in the offspring. They also found that one of the offspring's genes was "silenced"-- a gene associated with type 2 diabetes development. Nutrition, then, may have effects on gene expression that are linked to type 2 diabetes development [42].

3.2. Nutritional management of DM

In contemporary time, Medical Nutrition Therapy (MNT) is used to describe dietary prescriptions [43] .

MNT for diabetes aim to achieve the following objectives:

1. Achieve and maintain near normal blood glucose goals
2. Achieve and/ or maintain optimal blood lipid levels
3. Achieve and/ or maintain normal blood pressure
4. Prevent, delay or treat nutrition related complications
5. Provide adequate kcalories for achievement of reasonable body weight
6. Provide optimal nutrition for maximizing health and for growth, development, pregnancy, and lactation

Body of knowledge shows that, with respect to carbohydrates, the key emphasis of MNT for diabetes mellitus is on the total amount of carbohydrate in terms of energy intake [44].As far as the type of carbohydrates to be ingested is concerned, the guidelines for MNT in DM clearly stress the value of selecting vegetables, fruits and grains , so that the starches consumed will include adequate amounts of both fibre and micronutrients[43].

Research findings shows specific interests in the role that dietary fiber may play in the nutritional management of DM. Benefit of fiber were found with regard to glycaemic control, HDL and LDL cholesterol and triacylglycerols [45]. However, a 3- month study by Jenkins et

al.[46] did not find a metabolic advantage of high fiber over low fiber cereals. Also, a study carried out by Erasmus et al. [47],showed that treatment with guar gum does not lower the postprandial glucose level in both non- diabetic and diabetic Nigerian subjects.

3.3. Dietary principles for diabetes mellitus

The American Diabetes Association [7] gave the following guidelines:

3.3.1. Type 1 DM

Which can achieve much if the following dietary principles are observed ;

i. Integrate and syncronise with the time of action of insulin treatment – patient on insulin therapy should eat at consistent time simultaneously with the time of action of insulin preparation used. This will help to minimize the peak of blood glucose as well as incidence of hypoglycaemia.
ii. Reduce saturated fat because diabetics are prone to having coronary heart disease and dietary restriction may reduce the risk.
iii. Keep salt intake low: salt intake must be reduced by diabetics because it has high risk of developing hypertension. However, intake of essential nutrients should be adequate among growing patients.
iv. Exercise: For planned exercise, reduction in insulin dosage may be the preferred choice to prevent hypoglycemia. Additional carbohydrate may be needed for unplanned exercise. Moderate-intensity exercise increases glucose uptake by 2–3 mg · kg^{-1} · min^{-1} above usual requirements. Thus, a 70-kg person would need 8.4–12.6 g (10–15) carbohydrate per hour of moderate physical activity. More carbohydrate would be needed for intense activity.
v. Metabolic profile: Improved glycaemic control with insulin therapy is often associated with increased body weight. Because of the potential for weight gain to adversely affect glycaemia, lipids, blood pressure, and general health, prevention of weight gain is desirable.

3.3.2. Type 2 DM

A change in dietary regimen has a greater potential to improve type 2 diabetes , therefore, the following guidelines will serve a useful purpose.

Because many persons with type 2 diabetes are overweight and insulin resistant, medical nutrition therapy should emphasize lifestyle changes that result in reduced energy intake and increased energy expenditure through physical activity. Therefore, reducing body weight by eating few calories and taking regular exercise. Also, increased physical activity can lead to improved glycaemia, decreasing insulin resistance, and reduced cardiovascular risk factors.

i. Reduce saturated fat and maintaining a reduced plasma low density lipoprotein cholesterol levels.

ii. Eating low glycaemic index foods such as soya beans, apple, grapefruits, peas(groundnuts), increase intake of vegetables, fruits, legumes and whole grain cereal that may mostly have low glycaemic indices.
iii. Keep salt intake low
iv. Fried food is not good for diabetes patients . Wheat bread, lean meat, game meat (bush meat), green, leafy vegetables, garden egg, all these should be encouraged for DM patients.
v. Physical activity: Increased physical activity can lead to improved glycaemia, decreased insulin resistance, and reduced cardiovascular risk factors.

4. Epidemiological and laboratory studies

From the review by Kayode et al.(1), epidemiological studies (48) have reported that as nations become more affluent, the nature of the people's carbohydrate consumption changes such that the ratio of complex (starches) to simple carbohydrates decreases. It has been suggested that this change in dietary pattern is responsible for the occurrence of various diseases, such as atherosclerosis, diabetes and hyperlipidaemia. One proposed physiological basis underlying such suggestions is a traditionally held tenet that simple carbohydrates are more readily available for immediate absorption by the gut than are more complex carbohydrates and that they therefore produce a greater and faster rise in postprandial plasma glucose and insulin responses than do the supposedly more gradually digested and absorbed complex carbohydrate. Consequently, diets restricted in simple carbohydrates have been recommended in disease states in which control of plasma glucose and/or insulin is felt to be important. However, there is dearth of sufficient laboratory data to substantiate the role nutrition plays in the management of diabetes mellitus.

4.1. Recommendations and further studies

To be able to effectively manage diabetes with the aid of dietary control, patient's education, understanding, and participation is vital since the complications of diabetes are far less common and less severe in people who have well- managed blood glucose levels. Also, there is reduction in expenses incurred due to this metabolic disorder which research shows was a major drain on health and productivity – related resources of government and other employers of labour.

Given the associated higher risks of cardiovascular disease, lifestyle modifications(which includes smoking habits, sedentary life, lack of regular exercise etc,) are strongly recommended. Besides, regular exercise, coupled with blood pressure , cholesterol levels, body weight , HbA1C measurements is advocated among people with diabetes.

Omega-3 fatty acids may be protective against type 1 diabetes, but more studies would be necessary to confirm this finding. Eating high glycemic-index foods may accelerate the progression of type 1 diabetes, but this association should also be confirmed. Taking anti-oxidant supplements does not appear to reduce the risk of type 1 diabetes, but it is possible that a diet high in anti-oxidants may still be protective.

More research is highly imperative on the epidemiological and laboratory aspects of the role of nutrition in the management of diabetes mellitus.

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